34010

ORIGINAL
(Red)

WORK PLAN
ADDITIONAL TASKS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS)
FOR OPERABLE UNIT 2 (OU 2)

REVERE CHEMICAL SITE
NOCKAMIXON TOWNSHIP, PENNSYLVANIA

APRIL 27, 1994
Revised 6/30/94

DAMES & MOORE

DAMES & MOORE PROJECT NO. 19142-009

Received May 4, 1994
Ruth Flo[illegible]

AR300001

Revised 6/30/94

TABLE OF CONTENTS

ORIGINAL
(Red)

ORIGINAL
(Red)

1.0 INTRODUCTION

This Work Plan presents the scope of work for supplemental tasks related to the Remedial Investigation/Feasibility Study (RI/FS) for Operable Unit 2 (OU 2) at the Revere Chemical Site (Site) in Nockamixon Township, Pennsylvania. The scope of work presented herein will meet the specific requirements of the United States Environmental Protection Agency (USEPA) as detailed in a December 16, 1993, letter to *de maximis, inc. (de maximis)* and discussed during a meeting in Dames & Moore's Willow Grove, Pennsylvania office location on February 2, 1994. The scope of the supplemental tasks will focus on:

- Collecting sediment samples from the onsite tributaries to evaluate the potential for migration of mercury-contaminated sediment through surface water transport to offsite locations.

- Collecting additional hydrogeologic and groundwater quality data necessary to compare, on a relative basis, the efficacy and cost of active groundwater remediation (pump and treat) versus groundwater remediation achieved by natural processes (passive remediation) for the limited area of the Site where groundwater quality has been impacted by the organic compounds trichloroethene (TCE) and 1,2,4-trichlorobenzene (TCB).

The additional hydrogeologic evaluation will involve the application of a computer code to model the expected rate of natural processes (adsorption, attenuation, biodegradation) to reduce TCE and TCB concentrations in groundwater relative to concentration reductions achieved through pump and treat remediation.

The remainder of this Work Plan is divided into eight chapters. Chapter 2.0 reviews background information regarding the Site. Chapter 3.0 presents the objectives of the additional investigation planned for the Site. Chapter 4.0 details the rationale and procedures for the sampling and analysis of sediment in the onsite tributaries, and additional hydrogeologic investigation is discussed in Chapter 5.0. The selection, calibration, and use of a computer model to evaluate potential groundwater treatment scenarios are detailed in Chapter 6.0, and Chapter 7.0 presents a comparative evaluation of passive (natural) versus active (pump and treat) groundwater treatment methods. Chapter 8.0 discusses the reporting of the results for the planned additional investigation, and a schedule regarding Work Plan implementation is discussed in Section 9.0.

ORIGINAL (Red)

2.0 BACKGROUND

Dames & Moore has completed several phases of investigation at the Site on behalf of the Revere Steering Committee (RSC) in accordance with an Administrative Order by Consent (USEPA, Region III Docket No. III-89-02-DC) between USEPA and the RSC. The results of each phase of the RI have been submitted to USEPA for review and comment. Based on a review of the information and data pertaining to the various phases of investigation and subsequent correspondence and discussion with USEPA representatives, USEPA has approved portions of the final RI report (May 19, 1993) and the final FS report (July 7, 1993) as indicated in the December 16, 1993, letter to *de maximis*. The portions of the final RI/FS that have been approved pertain to contaminated soil areas, solid waste, and miscellaneous surficial debris. However, USEPA has not approved the portions of these reports that pertain to groundwater and mercury-contaminated sediment, and requires additional investigation regarding these media.

Based on the approval of only selected portions of the final RI report, USEPA has divided the Site into two Operable Units (OUs):

- Operable Unit 1 (OU 1) - Contaminated soil areas, solid waste, and miscellaneous debris.
- Operable Unit 2 (OU 2) - Groundwater and mercury-contaminated sediment.

USEPA recently issued a ROD (December 1993) for only OU 1, as portions of the final RI report that pertain to groundwater and mercury-contaminated sediment have not been approved by USEPA. A separate ROD will be issued for OU 2 upon completion of the additional RI tasks detailed in this Work Plan, and a review and approval of the results by USEPA.

3.0 OBJECTIVES

The objectives of the scope of work presented in this Work Plan are to further evaluate:

- Potential Site related impacts regarding mercury concentrations in sediment within the onsite tributaries.
- The anticipated reduction in TCE and TCB concentrations in groundwater through natural attenuation, adsorption, and/or biodegradation (passive remediation) versus active groundwater remediation through extraction and treatment.

The delineation of mercury concentrations in sediment present within the onsite tributaries is required based on the results of the RI Supplemental Sampling and Analysis Program (included in the final RI report) that indicated increased mercury concentrations (relative to background) in sediment at an offsite location immediately downstream of the Site property boundary. Additional hydrogeologic investigation is necessary to evaluate the efficacy and cost of groundwater extraction and treatment to remediate TCE and TCB in the shallow aquifer compared to a remedial alternative that relies on the anticipated natural processes that will reduce TCE and TCB concentrations in groundwater.

4.0 ADDITIONAL SEDIMENT EVALUATION

Dames & Moore has completed two separate phases of an RI, including a supplemental sampling and analysis program, at the Site on behalf of the RSC. Each phase of investigation has included the collection and analysis of sediment samples from the onsite tributaries and corresponding upstream locations to provide comparative background data. Based on a review of the results presented in the RI reports and related correspondence, USEPA has required that additional investigation be conducted to further evaluate stream corridor sediment prior to issuing a ROD for OU 2.

The following sections present background information and discuss the scope of work regarding further evaluation of sediment within the stream corridor. Information discussed and presented in the following sections focuses on only mercury, as mercury is the only compound potentially related to the Site that exists at concentrations that may represent an ecological concern to USEPA.

4.1 SUMMARY OF PREVIOUS INVESTIGATIONS AND RESULTS

During the Phase I RI conducted at the Site, sediment from the onsite tributaries was collected from seven locations (B1 through B7). The mercury concentrations detected in sediment samples from the east tributary (B2, B4, B5, and B6) ranged from non-detect (B2) to 1.00 milligrams per kilogram (mg/kg). In the west tributary sediment samples (B1, B3, and B7), mercury concentrations ranged from non-detect (B1) to 0.14 mg/kg.

During the Phase II RI (including the Supplemental Sampling and Analysis), a total of six sediment samples (TES001OA through TES006OA) were collected from the onsite tributaries. Mercury was detected in sediment samples TES003OA and TES004OA collected from the east tributary at concentrations of 0.06 mg/kg and 0.12 mg/kg, respectively. Sediment-bound mercury was detected in the west tributary samples (TES001OA, TES002OA, and TES002RA) at concentrations ranging from non-detect (TES001OA/TES002OA) to 1.87 mg/kg (TES002RA). Sediment samples collected downstream of the confluence of the two onsite tributaries (TES005OA, TES006OA, and TES006RA) contained mercury at concentrations ranging from non-detect (TES005OA) to 0.07 mg/kg (TES006OA). It is the detection of mercury at a concentration of 0.07 mg/kg in TES006OA that represents an ecological concern to USEPA.

4.2 SEDIMENT SAMPLING AND ANALYSIS

As discussed during the February 2, 1994, meeting and a subsequent telephone conference call (February 4, 1994) with biologists from USEPA and the United States Department of the Interior (DOI), Fish and Wildlife Service, the investigation of mercury in the sediment in the tributaries will be implemented using a phased approach. The initial phase will be limited to the collection and analysis of sediment samples from upstream (background) locations, onsite locations, and offsite locations between the southern property boundary and the confluence of the tributaries with Rapp Creek. The point of convergence of the tributaries with Rapp Creek occurs at an offsite location, beyond the southern property boundary. Subsequent phases of evaluation, such as sediment sampling and analysis within Rapp Creek to assess Site-related impacts to sediment quality, are contingent upon the results of mercury analyses for sediment samples collected from the tributaries.

The decision to defer any sediment sampling in Rapp Creek is based in part on the physical characteristics of the tributaries and Rapp Creek (exposed bedrock stream base, intermittent flow with predominant flow occurring during periods of substantial or sustained precipitation), the corresponding sediment transport and deposition characteristics of the streams, and the potential contribution of mercury-contaminated sediment to Rapp Creek from upstream sources, particularly the Penn Rare Metals Site. USEPA conducted a Site inspection at Penn Rare Metals in September 1988 (report dated August 1989) that included the collection and analysis of sediment samples from two locations within Rapp Creek. The results showed mercury present in sediment collected from a location within Rapp Creek that is upstream of the Penn Rare Metals Site (and therefore upstream of the Revere Site) at a concentration of 34.2 milligrams per kilogram (mg/kg). Additionally, a soil sample collected from the Penn Rare Metals Site at a depth of 0.8-foot below ground surface also contained mercury (0.21 mg/kg).

Based on the sediment transport and deposition characteristics of Rapp Creek and the documented detection of mercury-contaminated sediment within Rapp Creek upstream of the Revere Site, additional sampling and analysis of sediment downstream of the confluence of the Revere tributaries and Rapp Creek will not provide a definitive determination of impacts to Rapp Creek regarding transport of mercury-contaminated sediment from the Revere Site.

After conveying the information discussed above to USEPA and DOI biologists during the February 4, 1994, conference call, they requested the collection and analysis of sediment samples from the floodplains (riparian areas) adjacent to the onsite tributaries to evaluate mercury concentrations. The collection of floodplain samples was proposed to provide an indication of the historic deposition of fine-grained sediment along the tributaries that has occurred during periods of increased flow velocity. However, during a Site reconnaissance on

March 22, 1994 to select sediment sampling locations, DOI (Ms. Cindy Rice) indicated that sediment samples should be collected from areas within the streams and along the stream banks where stream flow velocities were reduced and fine-grained sediment could accumulate. Floodplain sediment sampling is no longer required by DOI based on visual observation of the physical characteristics of the tributaries. These characteristics suggest that the floodplains are not likely to receive sediment transported via surface water flow in the tributaries except under extreme flow conditions and velocity.

4.2.1 Access Agreement

Sampling locations proposed beyond the southern property boundary are situated on private property. Dames & Moore, on behalf of the RSC, will need to obtain an access agreement from the owner of that property to obtain the sediment samples. Dames & Moore previously reviewed township records prior to implementing the supplemental sampling and analysis program to identify the property owner and was granted permission to access the privately-owned property for the purpose of sample collection. Based on the cooperation of the property owner during the previous sampling event, we do not anticipate problems associated with access restrictions. However, an access agreement will be obtained prior to the collection of sediment samples from offsite locations.

4.2.2 Tributary Sediment Sampling and Analysis

Dames & Moore will collect and analyze sediment samples from each of the tributaries at locations upstream of the Site property boundaries to provide a background database for sediment quality with regard to mercury. The background samples will provide mercury data for sediment within the tributaries upstream of the Site, negating potential Site influence on mercury concentrations. Sediment samples will also be collected from each of the tributaries adjacent to the process area, prior to the confluence of the two tributaries, and downstream of the confluence of the tributaries prior to the southern property boundary. These sampling locations will be approximately the same as during the Phase II RI and the Supplemental Sampling and Analysis Program (TES001 through TES006).

Additional sediment samples will be collected from the tributary at locations downstream of the Site southern property boundary prior to Rapp Creek. Data obtained through the collection of those samples will be evaluated with regard to the background data and data for samples collected from the tributaries at locations within the Site property boundaries to assess the potential for mercury-contaminated sediment to migrate to off-site locations via surface water transport.

ORIGINAL (Red)

Dames & Moore will collect sediment samples from within the onsite tributaries and/or along the banks of the tributaries where fine-grained sediment accumulations are present and submit the collected samples for laboratory analysis for only mercury. Samples will be collected sequentially from downstream to upstream locations. The number of samples collected and sampling station locations situated between the Site southern property boundary and Rapp Creek will be selected in the field based on the depositional features observed. As discussed during the March 22, 1994, Site reconnaissance, DOI will be present during the sediment sampling program and will concur with sampling locations selected in the field. Sediment sampling is tentatively scheduled to be initiated on May 9, 1994.

Sediment sampling, the collection of quality assurance samples, and sample custody procedures will be conducted in accordance with the procedures presented in Appendix A of the Phase II RI/FS Work Plan for the Site (November 26, 1990) and detailed in section 10.6.2 of the final RI report. The following items summarize the field procedures for collection of the tributary sediment samples:

- Sediment will be collected from the base of each stream channel with either a stainless steel trowel or a gloved hand.

- Sediment will be passed through a No. 60 brass sieve (wet sieve) at each sampling location to limit sampling bias associated with variations in grain size.

- After sieving, sediment samples will be placed in laboratory-prepared glass sample bottles, and the bottles will be immediately stored in a cooler at 4° C.

- A chain of custody form will be filled out and placed in the cooler to accompany the samples through the shipping and laboratory process.

- Sample coolers will be transported to the laboratory on the day of sample collection.

Sediment samples collected will be submitted to Environmental Testing and Certification Corporation (ETC) in Edison, New Jersey for laboratory analyses for mercury concentrations. ETC conducted laboratory analyses for sediment samples previously collected from the onsite tributaries as part of the Phase II RI and the supplemental sampling and analysis program. Laboratory analyses for sediment samples collected will be expedited so that analytical data can be reviewed and an assessment made regarding the need for subsequent phases of stream corridor sediment sampling and analysis.

5.0 ADDITIONAL HYDROGEOLOGIC INVESTIGATION

Based on the results of a regional groundwater monitoring study completed in the vicinity of the Site, including the measurement of groundwater elevations and geophysical logging of selected monitoring wells at the Site, the flow system at the Site has been described by the United States Geological Survey (USGS) as a two aquifer system (termed the upper and lower potentiometric aquifers). The USGS interprets these aquifer systems to be laterally continuous and extensive. As indicated in the recently issued ROD for OU 1 and discussed during the February 2, 1994, meeting, USEPA agrees with the USGS interpretation of Site hydrogeology.

Based on the two aquifer system interpretation of Site hydrogeologic conditions, groundwater in the upper aquifer flows laterally toward and discharges to the onsite tributaries across the entire Site, and the base of the upper aquifer is defined by bedrock units referred to by USEPA in the ROD for OU 1 as unfractured black shales. Therefore, additional hydrogeologic investigation and computer modeling (discussed in Chapter 6.0) will be conducted to simulate two-dimensional horizontal (planar) groundwater flow and contaminant transport in only the upper aquifer.

Although the lateral (tributaries) and vertical (black shales) boundary conditions for the upper aquifer are established, additional data are required to accurately calibrate the TARGET computer code and apply the code to model groundwater flow and transport mechanisms given Site hydrogeology and groundwater chemistry. The following bullet items present the objectives for implementing this additional investigation of Site hydrogeologic and groundwater quality conditions:

- Collect additional physical and chemical hydrogeologic data to support the calibration and development of a computer model.

- Further define the horizontal extent of TCE and TCB in the upper aquifer.

- Verify the Site conceptual model.

The remainder of this chapter describes the methods that will be used to acquire this additional hydrogeologic and groundwater quality data. The additional investigation will involve multiple tasks as discussed in the following sections. A summary of previous investigation results with regard to Site hydrogeology and groundwater quality is provided in Section 5.1. Section 5.2 details the procedures for production well modification. Monitoring well drilling and installation are discussed in Section 5.3. The procedures for the evaluation of infiltration recharge are provided in Section 5.4. Section 5.5 details the procedures for borehole video surveys and geophysical logging. Aquifer characterization methods are described in Section 5.6. Water elevation monitoring and groundwater sampling and analysis is addressed in Section 5.7.

5.1 SUMMARY OF PREVIOUS INVESTIGATIONS AND RESULTS

During the various phases of the RI conducted at the Site, 12 monitoring wells have been installed and monitored, one of which was abandoned (MW-6) based on the results of sampling and analysis conducted as part of the Phase IA RI. In addition to the 11 existing monitoring wells, the production well has also been monitored for groundwater elevations and sampled and analyzed to evaluate groundwater quality. Seven of the existing monitoring wells (MW-1 through MW-5, MW-7, and MW-12) are situated in the upper aquifer, with the remaining four wells (MW-8 through MW-11) screened below the base bedrock unit (black unfractured shales) of the upper aquifer. A borehole video survey and geophysical logging of the production well indicated the presence of water-bearing fractures in both the upper and lower aquifers.

The results of sampling and analysis indicate that the presence of TCE and TCB in groundwater is limited to the upper aquifer. The extent of TCE concentrations in groundwater is restricted to a limited portion of the process area (MW-2, MW-4, MW-7, MW-12, and the production well). The maximum TCE concentration detected is 170 μg/l in MW-4, and MW-4 has consistently shown the greatest TCE concentrations detected. Groundwater data for the remaining wells in the upper aquifer indicate either non-detect levels of TCE, TCE at concentrations marginally above the detection level of 5 μg/l, or estimated TCE concentrations (less than detection limits). TCB has been detected in only MW-4 and the upper fracture zone of the production well. The highest concentrations of TCB detected in these wells during the Phase II RI were 150 μg/l and 82 μg/l, respectively.

5.2 PRODUCTION WELL MODIFICATION

Production well modification will involve the construction of two separate monitoring wells within the existing production well borehole, situated east of monitoring well MW-12 (see Figure 1). Modification of the production well will provide two additional groundwater monitoring points, one each for the upper and lower aquifers, and will eliminate the potential contaminant migration pathway represented by the production well as it now exists.

The production well will be modified by placing PVC screen and riser pipe casing within the existing well borehole at appropriate depth intervals to monitor both the lower and upper aquifers at the Site. Based on the 6-inch diameter of the production well borehole, well modification will be conducted using 2-inch diameter PVC casing and screen to provide a sufficient annular space during well construction procedures (sand pack emplacement, grouting, etc.).

Modification of the production well to monitor the lower aquifer will involve placing cement/bentonite grout from the base of the borehole (approximately 390 feet below ground surface [bgs]) to a depth of approximately 335 feet bgs. Grout will be introduced into the borehole using tremie pipe procedures. The volume of grout emplaced in the borehole will be equivalent to approximately 75 percent of the total volumetric capacity of the borehole represented by the 315 to 390 foot depth interval. This conservative volumetric estimate for grouting will prohibit potential introduction of grout into the water-bearing zone at 314 feet bgs.

Following verification of the grout level in the well borehole using a tag line, a 3-foot thick bentonite pellet seal will be placed above the grout, and approximately 2 feet of No. 1 sand will be placed above the bentonite seal. The bentonite and sand pack will be placed above the grout using the tremie pipe, and the appropriate placement of the bentonite seal and sand pack will also be verified with a tag line. The monitoring point for the lower aquifer will consist of 0.010-inch slotted PVC well screen extending from 310 to 330 feet bgs, intersecting the horizontal fracture at approximately 314 feet bgs. The base of the well screen will be capped. PVC riser pipe casing will extend from the top of the screened interval to approximately 2 feet above ground surface. Sand pack will be placed within the annular space of the borehole around the well screen and extend approximately 2 feet above the top of the screened interval. A 3-foot thick bentonite pellet seal will be placed above the sand pack, and the annular space of the borehole will be grouted with a cement/bentonite grout from this bentonite pellet seal to approximately 80 feet bgs. Each of these procedures will be conducted using a tremie pipe, and tag lines will be used to verify appropriate depth placement.

A monitoring point for the upper aquifer will be constructed in the same manner with the following specifications:

- Bentonite pellet seal - 77 to 80 feet bgs
- Sand pack - 77 to 58 feet bgs
- PVC well screen - 75 to 60 feet bgs
- Bentonite pellet seal - 56 to 58 feet bgs
- PVC riser pipe casing - 60 feet bgs to 2 feet above ground surface
- Cement/bentonite grout - 56 feet bgs to ground surface

Following well modification within the production well borehole, the newly constructed wells will be developed. Well development will be conducted in accordance with the procedures detailed in Appendix A of the Phase II RI/FS Work Plan, with the exception of containerizing and storing water pumped from the wells. Based on analytical data for groundwater samples collected from the production well during the Phase IIA RI and the Supplemental Sampling and Analysis Program, well development water will be discharged to the ground surface. Although TCB was detected in the upper fracture zone (shallow aquifer) of the production well borehole, the discharge of development water to the ground surface will not result in additional groundwater quality degradation as this water will ultimately percolate to the shallow aquifer.

5.3 MONITORING WELL DRILLING AND INSTALLATION

Based on the conceptual model of Site hydrogeology, only six monitoring points exist in the upper saturated portion of the bedrock aquifer: four monitoring points within the process area and one monitoring point in each of the spray fields. Dames & Moore will monitor the drilling and installation of four additional monitoring wells, designated MW-13 through MW-16, to further characterize the physical properties and groundwater quality within the upper aquifer. The proposed well locations are shown on Figure 1. These well locations were selected to further delineate the horizontal boundary of TCE and TCB concentrations in the upper aquifer and provide data necessary to support the calibration and development of a defendable computer code to simulate groundwater flow and TCE transport under various remedial scenarios, including the monitoring alternative.

At each of the proposed well locations, Dames & Moore will estimate the depth (below ground surface) to the top of the black shale unit that defines the vertical boundary of the upper aquifer based on lithologic descriptions of the bedrock recorded during Phase I and Phase II RI monitoring well drilling and the borehole video survey and geophysical logging data obtained during the Phase II RI. Each of the proposed wells will be advanced to a depth equivalent to approximately 15 feet above the top of the black shale unit, or until a water-bearing fracture(s) of substantial yield (on the order of 1 gallon per minute [gpm] or greater) is encountered. Drilling will be conducted using air-rotary techniques and equipment. If a borehole drilled to the predetermined depth does not indicate that the influx of water is substantial (less than 1 gpm), that borehole will be abandoned using cement/bentonite grout and an alternate, nearby location will be selected for well placement. Drilling procedures will be in accordance with those specified in the Phase II RI/FS Work Plan prepared by Dames & Moore, dated November 26, 1990.

The results of straddle-packer testing conducted during the Phase II RI indicated the permeability of the upper saturated portion of the bedrock aquifer is low (ranging from 0.013 feet/day to 12.4 feet/day), and the hydraulic conductivity of the upper aquifer is directly proportional to the degree of fracturing and magnitude of individual fractures or fracture zones. Because the degree of fracturing and the capacity to produce water is generally limited over the entire saturated portion of the upper aquifer, straddle-packer testing to isolate and evaluate individual zones within the newly installed wells will not be conducted, and these wells will not be modified to isolate an individual zone of increased permeability within the well boreholes using PVC screen and rising pipe casing. The newly installed wells will consist of open-bedrock boreholes with protective steel casing and grout seal to inhibit the introduction of surface water into the bedrock borehole other than through percolation.

Following installation, each of the wells will be developed in accordance with procedures detailed in Appendix A of the Phase II RI Work Plan. Water pumped from the wells during development will be discharged directly to the ground surface. The discharge of development water directly to the ground surface is proposed versus containing and storing the water based on the limited detection of TCE and TCB in the upper aquifer. Additionally, discharge to the ground surface will only result in the infiltration and percolation of the development water to the aquifer where it originated.

The protective casing of each of the wells drilled as part of the additional hydrogeologic investigation will be surveyed to determine horizontal location and vertical elevation. Surveying will be conducted by Boucher & James, Inc. of Doylestown, Pennsylvania. Boucher & James completed all previous surveying work conducted at the Site during the RI. A permanent reference mark will be incised on the casing from which the elevation is surveyed. This mark will serve as a reference mark for groundwater elevation monitoring. The vertical elevation of the protective steel casing and the adjacent ground surface will be surveyed to the nearest 0.01 foot. The horizontal location of each well will be surveyed within 0.10 foot accuracy.

5.4 INFILTRATION RECHARGE EVALUATION

As discussed during the February 2, 1994, meeting and requested by USEPA, an evaluation of infiltration recharge response for the upper aquifer will be conducted. This evaluation will involve monitoring groundwater elevation changes using pressure transducers connected to electronic data loggers (that continuously record changes in static water elevations). The recorded responses will be evaluated relative to precipitation events. At the completion of production well modification, one transducer will be placed in the newly constructed well within the upper aquifer well of the production well borehole. Additionally, one transducer will be placed in MW-7 and MW-2 to monitor water level changes in the upper aquifer. A rain gauge will be established at an onsite location and precipitation will be recorded daily to allow for a comparison of water level response for the upper aquifer with regard to precipitation infiltration. The data collected will be used to assess the aquifer influx value as input into the TARGET computer code. The duration of the infiltration recharge evaluation is anticipated to be approximately three months.

5.5 BOREHOLE VIDEO SURVEY AND GEOPHYSICAL LOGGING

A borehole video survey and geophysical logging will be conducted for each of the four wells drilled as part of the additional hydrogeologic investigation. Dames & Moore anticipates that these tasks will be conducted by the USGS on behalf of USEPA, similar to the Phase II RI during which the USGS performed geophysical logging for several wells at the Site. Dames & Moore has been informed that the USGS has recently obtained a downhole television camera and they routinely perform borehole video surveys and geophysical logging on behalf of USEPA.

The borehole video survey will be conducted to provide a continuous photographic log of the lithologic sequence encountered at the four newly-installed monitoring wells at the Site. These surveys will be conducted in a manner similar to the surveys conducted during the Phase II RI at the Site.

Geophysical logging will be conducted using the same methods and techniques of evaluation used by USGS, as detailed in Section 5.5 of the Phase II RI Report. The Mount Soporis digital geophysical logger will be employed for the downhole geophysical surveys. The operation of the Mount Soporis logger is described in the manual entitled Instructional Manual Model 2500 Logger, available from the USGS District Office in Lemoyne, Pennsylvania. The following list summarizes the geophysical logging to be performed at the Site:

- Caliper Logs.
- Natural Gamma-Ray Logs.
- Temperature Logs.
- Fluid Resistivity Logs.
- Brine Trace Logs.

5.6 AQUIFER CHARACTERIZATION

Slug testing will be conducted at each of the wells installed in the upper aquifer to provide data for an evaluation of aquifer hydraulic conductivity (K). These tests will involve the introduction of a slug into the borehole and measuring aquifer response upon the introduction and removal of the slug. The aquifer response will be measured using pressure transducers connected to e..ctronic data loggers to continuously record changes in static water elevations. Data recorded .ill be evaluated to obtain K values for the upper aquifer in the vicinity of each of the wells. These values will be compared to and supplement those K values previously obtained through Phase II RI straddle-packer testing. In addition, these data will be used as input data for computer modeling.

If any of the wells installed in the upper aquifer intersect a water-bearing fracture of substantial yield (on the order of 10 gpm), pumping tests may be conducted to obtain accurate values for the transmissivity and storativity of the aquifer. Details regarding the potential implementation of pumping tests will be provided to USEPA as an addendum to this Work Plan.

5.7 GROUNDWATER ELEVATION MONITORING/SAMPLING AND ANALYSIS

Groundwater elevation monitoring and groundwater sampling and analysis will be conducted at the completion of well drilling and downhole geophysical and hydrogeological evaluations. Groundwater elevation and groundwater quality data are required to calibrate the TARGET computer code to the extent that assumptions made as part of the modeling effort are supportable and defendable. Sampling and analysis and evaluation of the newly installed wells will further define the lateral boundaries for TCE and the potentiometric surface of the upper aquifer. The collection of these data, in conjunction with the physical hydrogeologic data obtained, will allow for model calibration based on current conditions at the Site. The most recent data for groundwater elevations and groundwater quality for the upper aquifer were obtained in May 1992.

5.7.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring will be conducted for all onsite wells bi-weekly for two months. The depth to water in each onsite monitoring well will measured to the nearest 0.01 foot relative to an established reference point on the well casing using a portable reel-type electric water level probe. The groundwater elevation of each well will then be calculated by subtracting the depth to ground water from the elevation of the established reference point.

5.7.2 Groundwater Sampling and Analysis

One round of groundwater sampling and analysis will be conducted for each of the wells monitoring the upper aquifer. Groundwater samples will be analyzed for volatile organic compounds (VOCs) using USEPA Method No. 524.2 and base/neutral extractable organic compounds by USEPA Method No. 625. Laboratory analysis will also be conducted to evaluate total organic carbon (TOC), methane, ethane, and ethylene concentrations in groundwater. Additionally, groundwater samples will be field evaluated for pH, temperature, oxidation/reduction potential (Eh), specific conductance, and dissolved oxygen (DO). Measurement of field parameters will be conducted before purging and following sample collection. The results of analyses for TOC, methane, ethane, and ethylene, and field data for Eh and DO may provide an indication of the potential for TCE and TCB biodegradation. Well purge water will be discharged directly to the ground surface.

If the results of groundwater sample analyses show substantial variation to those data obtained during previous sampling events, a second round of groundwater sampling and analyses may be conducted to confirm the data collected following installation of the additional wells. A period of at least one month will elapse between sampling events, and samples collected during the subsequent event will be analyzed for the same suite of parameters as those indicated above.

6.0 COMPUTER MODELING

The objectives of conducting computer modeling are to:

- Construct and calibrate a ground-water flow and contaminant transport model of the upper saturated flow system beneath the Site.

- Predict and comparatively evaluate the effectiveness and cost of groundwater remediation under various extraction and treatment scenarios relative to a monitoring remedial alternative.

Based on information and data obtained through the implementation of investigative measures conducted during various phases of the RI, modeling will be performed under the assumption that the groundwater flow system at the Site behaves as an equivalent porous medium.

6.1 COMPUTER MODEL SELECTION

Based on the conceptual Site model and boundary conditions of Site hydrogeology in the upper aquifer, the transient analyzer of reacting groundwater and effluent transport - TARGET (Dames & Moore, 1985) will be used to simulate groundwater flow and contaminant transport in the upper most saturated unit of the fractured bedrock aquifer system. The fractured bedrock aquifer system at the Site will be treated as an equivalent porous media (EPM). These simulations will be conducted using TCE as a representative constituent within the groundwater flow and transport system. The TARGET computer code manual is provided as Appendix A, and Appendix B provides information regarding peer review and validation of TARGET.

TARGET solves for two-dimensional horizontal groundwater flow in a homogenous anisotropic unconfined aquifer with sources and sinks using the following equation:

$$K_{xx}\frac{\partial^2 H}{\partial x^2} + K_{yy}\frac{\partial^2 H}{\partial y^2} = S_s\frac{\partial H}{\partial t} + q_b \qquad (1)$$

where:

H	=	hydraulic head	[L]
S_s	=	specific storage	[L^{-1}]
K_{xx}	=	hydraulic conductivity in the x-direction	[LT^{-1}]
K_{yy}	=	hydraulic conductivity in the y-direction	[LT^{1}]
q_b	=	volume flow rate per unit volume of source or sink	[T^{-1}]

TARGET simulates reactive transport of TCE using equation (2), below. The horizontal two-dimensional form of the advection-dispersion equation for reactive dissolved constituents in a saturated, homogenous, anisotropic porous medium can be written as follows:

$$D_L\frac{\partial^2 C}{\partial x^2} + D_T\frac{\partial^2 C}{\partial y^2} - v_i\frac{\partial C}{\partial x} - \lambda CR = R\frac{\partial C}{\partial t} + \frac{C'W*}{\eta} \qquad (2)$$

where:

v_i	=	$\frac{K_{ii}}{\eta}\frac{\partial H}{\partial x_i},\ i = 1,2$	(3)
	=	pore water velocity from equation (1)	[LT^{-1}]
C	=	solute concentration	[ML^{-3}]
C'	=	solute concentration in source or sink fluid	[ML^{-3}]
W*	=	volume flow rate per unit volume of source or sink	[T^{-1}]
η	=	effective porosity	[dimensionless]
R	=	retardation factor	
	=	$\left(\frac{1+\rho_b K_d}{\eta}\right)$	[dimensionless]

t	=	time	[T]
D_L	=	longitudinal dispersion coefficient	
	=	$\alpha_L v_i + D*$	$[L^2T^{-1}]$
α_L	=	longitudinal dispersivity	[L]
D_T	=	transverse dispersion coefficient	
	=	$\alpha_T v_i + D*$	$[L^2T^{-1}]$
α_T	=	transverse dispersivity	[L]
$D*$	=	molecular diffusion coefficient	$[L^2T^{-1}]$
ρ_b	=	bulk density of the solid	$[ML^{-3}]$
K_d	=	TCE distribution coefficient	$[M^{-1}L^3]$
	=	K_{OC} x F_{OC} (Lyman et.al, 1982)	
F_{OC}	=	fraction organic content	
K_{OC}	=	organic carbon partition coefficient	
	=	$\dfrac{\mu g\ absorbed\ /\ g\ organic\ compound}{\mu g\ /\ mL\ solution}$	$[M^{-1}L^3]$
	=	126 for TCE (EPA 1986)	
λ	=	ln2/half-life	$[T^{-1}]$
half-life TCE	=	0.9 - 2.5 years (Vogel et.al, 1987)	[T]

The mass transport equation above describes the change in the mass concentration of any particular species, such as TCE, within a migrating mass of contaminants with respect to time. The change in mass concentration of any particular species with respect to time is a function of an advective term and a dispersive term. Chemical interactions are considered in the forms of an organic carbon partitioning coefficient (126 for TCE) and a biodegradation term, which is known to vary from 0.9 to 2.5 years for TCE (Vogel et.al 1987, EPA 1986). The advective term is represented by "$v(\partial C/\partial x)$" in the mass transport equation, where "v" represents groundwater velocity, and "$\partial C/\partial x$" is the change in concentration "C" of the specific species (TCE) with respect to distance in the "x" direction. The dispersive term is represented by a component in the "x" or longitudinal direction, "$D_L(\partial^2C/\partial x^2)$", and a component in the "y" or transverse direction, $D_T(\partial^2C/\partial y^2)$".

6.2 COMPUTER MODEL CALIBRATION

Plan view maps showing water-level elevations and TCE distribution in the upper aquifer will be used to calibrate a two-dimensional model of groundwater flow and TCE transport. The model will consist of an upper surface corresponding to the water table and a lower surface defined by the top of the "black unfractured shale beds" referred to by USEPA in the ROD for the OU 1. The model boundaries will be located along groundwater flow paths at the Site perimeter and along the east and west onsite tributaries. Values of hydraulic conductivity (K), specific storage (S_s), porosity (n), and specific yield (S_y) will be initially estimated using field data. Simulations of steady-state groundwater flow will be initially conducted assuming that K does not vary with direction. Additional simulations will be conducted assuming $K_{xx} = nK_{yy}$, where n will vary from 1/10 to 10. Smaller zones within the model domain may require additional adjustments to K_{xx} and K_{yy} to improve the fit between the simulated and actual water-level elevations. Recharge from precipitation will be estimated using available published references and data collected during the water elevation/infiltration recharge evaluations to be conducted during the additional hydrogeologic investigation to further evaluate OU 2 (described in Section 5.5). These constants will be used as input data for the TARGET numerical model and adjusted such that the simulated water-level elevations match the observed data. TARGET will also be used to calculate cumulative fluxes along discharge boundaries (rivers and streams) where the water-table elevation exceeds the boundary elevation. Where the reverse is true, TARGET will track and estimate streamflow losses. After the groundwater flow portion of the model is calibrated, the longitudinal and transverse dispersivity coefficients for simulations of TCE transport, α_L and α_T, and λ and R will be adjusted such that the simulated TCE concentrations match the observed values. It should be noted that values of R estimated via equation (2) can be checked by knowing the average groundwater velocity v and the velocity of the contaminant v_C. Davis and DeWiest (1966) have shown that $R = v/v_C$. The estimated retardation factor using the partioning coefficient should equal that using the estimated velocity of the TCE mass.

7.0 COMPARATIVE EVALUATION OF MONITORING VERSUS PUMP AND TREAT

A monitoring scenario (passive remediation) will be simulated for an extended period of time and the results will be used for baseline comparison purposes. A second scenario will be simulated in which a series of extraction wells, located around and/or within the limits of the plume, will be pumped for various time periods. The simulated results will be compared to the baseline scenario to assess improvements in TCE containment and/or removal relative to monitoring. The comparison will consider effectiveness (e.g., duration of treatment necessary to achieve a remedial goal) and cost. The effects of biodegradation will be assessed for each simulation for values of λ ranging from 10^{-4} to 1 (see equation (2)). The results will be included in the comparison of passive versus active remediation and will be used to guide the selection process and provide recommendations for remedial actions for OU 2.

8.0 QUALITY ASSURANCE/QUALITY CONTROL

8.1 HEALTH AND SAFETY GUIDELINES

Work conducted during the supplemental sampling and analysis program will be performed following the health and safety guidelines presented in the Site Health and Safety Plan (HASP). The Site HASP was previously provided as Appendix B to the Phase II RI/FS Work Plan.

8.2 QUALITY ASSURANCE/QUALITY CONTROL SAMPLING

Quality Assurance/Quality Control (QA/QC) samples will be collected during the additional investigation of OU 2 to provide control over the collection of environmental data. The collection of QA/QC samples is necessary to validate and qualitatively interpret the data obtained. The number, type, and rationale for the collection of QA/QC samples will be conducted in accordance with the procedures contained in Appendix A of the Phase II RI/FS Work Plan and the laboratory Quality Assurance Project Plan (QAPP). Samples collected as part of QA/QC procedures will include replicate samples, matrix spike/matrix spike duplicate samples, equipment rinseate blank (field blank) samples, and trip blank samples.

9.0 REPORTING

The results of the additional investigations conducted in accordance with this Work Plan will be submitted to USEPA and the Pennsylvania Department of Environmental Resources (PADER). The results of investigation and data obtained will be evaluated and reported with regard to existing data collected during previous investigations, to the extent practical. The report will include conclusions pertaining to potential Site-related impacts to Rapp Creek associated with mercury-contaminated sediment transport via the onsite tributaries, and the efficiency and cost-effectiveness of groundwater remediation using pump and treat technology.

10.0 SCHEDULE

Dames & Moore will commence Work Plan implementation upon receiving USEPA approval of the indicated scope of work. The additional investigation (including report preparation) will be completed approximately 23 weeks following USEPA approval of the Work Plan.

A tentative schedule for implementation and completion of the Work Plan is presented below. Note that the initiation of field activities detailed in this Work Plan is contingent upon Site conditions and drilling rig accessibility. Current Site conditions preclude monitoring well drilling due to access constraints represented by the saturated overburden deposits. The RSC will notify USEPA of the date for initiation of field operations.

Task	Weeks after Receiving USEPA Approval
Mobilization/Access Agreement	0-1
Sediment Sampling and Analysis[(1)]	1-2
Infiltration Recharge Evaluation	1-13
Production Well Modification	1-2
Monitoring Well Drilling/Development	2-4
Surveying	4-5
Borehole Video and Geophysical Logging[(2)]	4-7
Groundwater Elevation Monitoring	6-14
Groundwater Sampling	6-10
Laboratory Analysis	2-16
Aquifer Characterization	7-9
Computer Modeling	16-20
Report Preparation	16-23

Notes:

1. Schedule for sediment sampling and analysis is contingent upon receipt of access agreement.
2. Schedule for borehole video surveys and geophysical logging is contingent upon USGS availability.

11.0 REFERENCES

Davis, S.N., and R.J.M. DeWiest, 1966. Hydrogeology, 463 pp. John Wiley, New York.

Dames & Moore, 1985. Target. Physical and Mathematical Background of Two-Dimensional and Three-Dimensional Variably Saturated Density Coupled Models, October 1985.

EPA, 1986. Superfund Public Health Evaluation Manual. EPA/540/1-86/060

Lyman, W.J., Reehl, W.F., and D.H. Rosenblatt, 1982. Handbook of Chemical Property Estimation Methods, McGraw-Hill Company, New York.

Vogel, T.M., Criddle, C. S., and P. L. McCarty, 1987. Transformations of halogenated aliphatic compounds. Env. Sci. Tech. V.21, N.8, pp. 722-736.

o O o

This Work Plan was prepared by:

DAMES & MOORE

Ralph T. Golia
Managing Associate, Geosciences

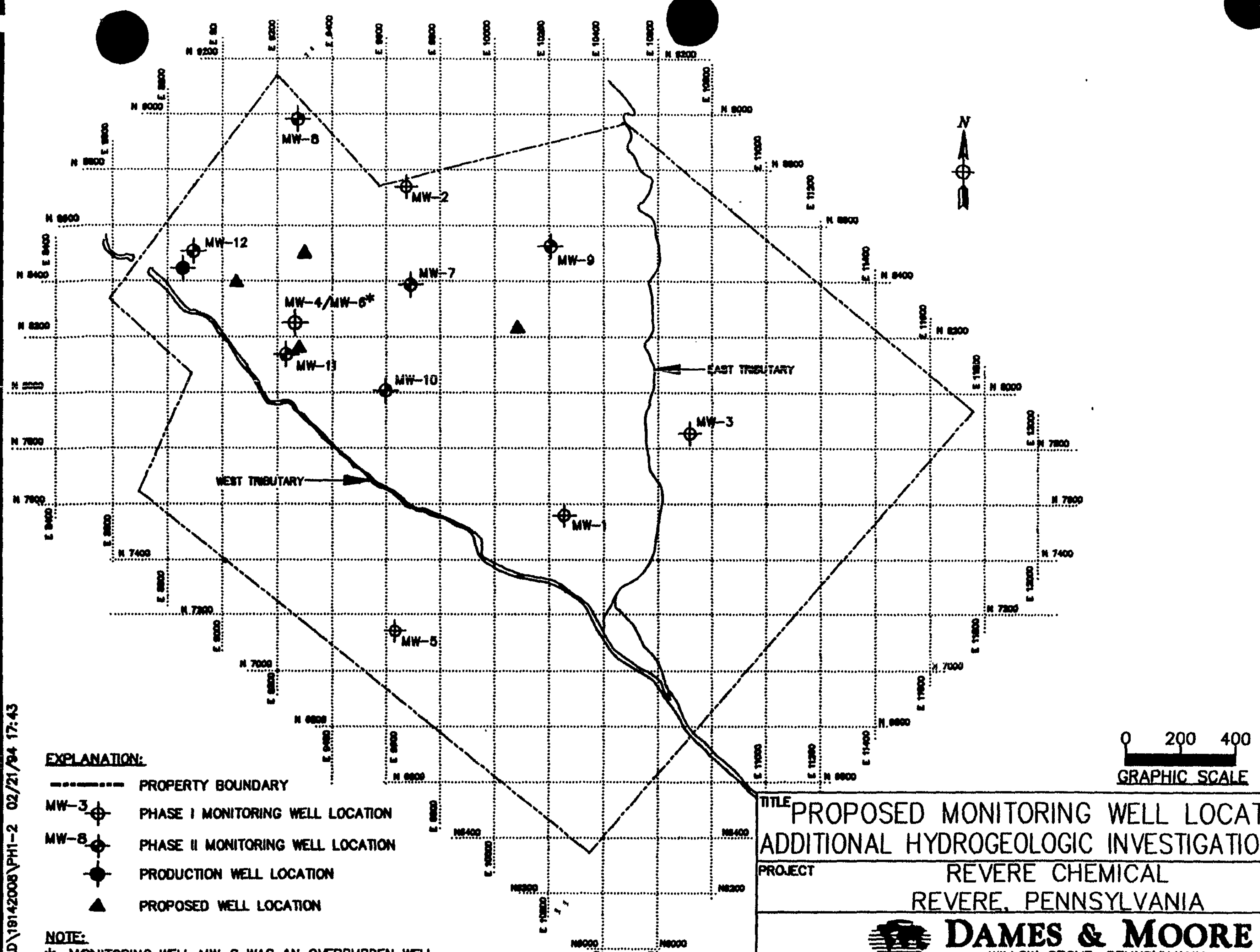
Mark Piazza
Project Manager

RTG/MP:cmc

(Red)

F
I
G
U
R
E
S

AR300023



EXPLANATION:

- PROPERTY BOUNDARY
- MW-3 PHASE I MONITORING WELL LOCATION
- MW-8 PHASE II MONITORING WELL LOCATION
- PRODUCTION WELL LOCATION
- PROPOSED WELL LOCATION

NOTE:

* MONITORING WELL MW-6 WAS AN OVERBURDEN WELL INSTALLED DURING THE PHASE 1A INVESTIGATION, AND DECOMMISSIONED AFTER REVIEW OF THE ANALYTICAL RESULTS INDICATED THE ABSENCE OF ANY COMPOUNDS OF CONCERN.

(S)C:\ACAD\19142008\PH1-2 02/21/94 17:43

TITLE PROPOSED MONITORING WELL LOCATIONS ADDITIONAL HYDROGEOLOGIC INVESTIGATION-OU 2			
PROJECT REVERE CHEMICAL REVERE, PENNSYLVANIA			
DAMES & MOORE WILLOW GROVE, PENNSYLVANIA			
SCALE AS SHOWN	DWN. BY R.G.B.	JOB NO. 19142-008	
DATE 2-21-94	APPR. BY M.P.	FIG. NO. 1	

ORIGINAL

AR300024